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(54) Fin stabilised penetrator

(57) A fin stabilised penetrator projectile with a high length to diameter ratio in which the projectile body (12) has at least three narrow stabilising strips (20) extending longitudinally along the external surface of the projectile body. The strips provide flexural stability. The strips (20) can be extended towards the rear and formed with increased span to provide tail fins (22). The rigidification of slender inertia projectiles thus achieved enables penetrators with a length to diameter ratio of over thirty to be fired without flexural resonant oscillations. The strips may comprise at the front a high temperature resistant material e.g. a steel alloy or a titanium alloy and at the rear a light aluminium alloy. The strips may be attached to a thin casing (not shown) surrounding the projectile body and are sheared off with the casing as the projectile penetrates the target. The projectile body may be cylindrical or tapered and may include annular fracture zones.

FIG. 4

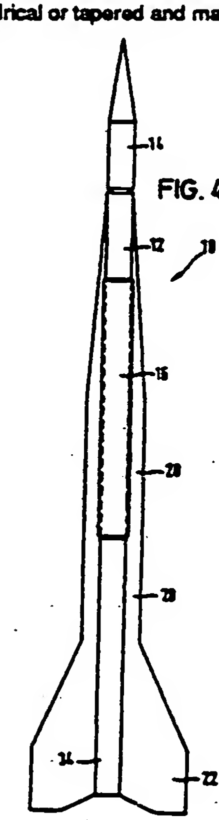

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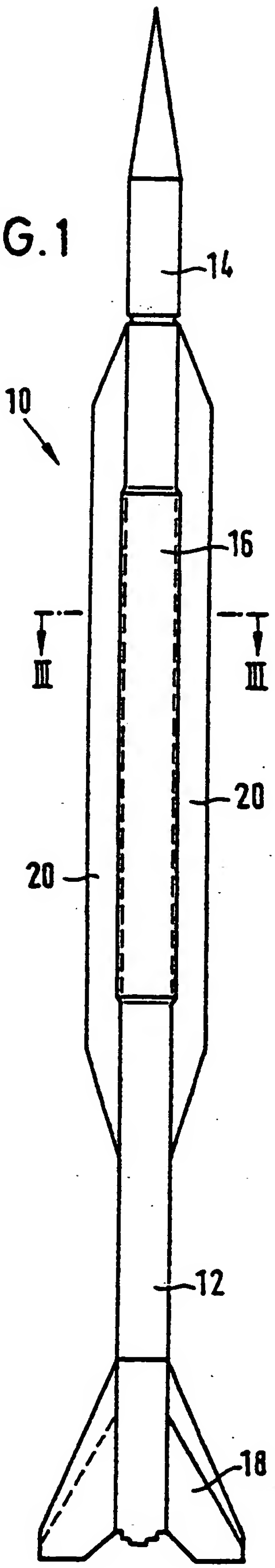
FIG.1



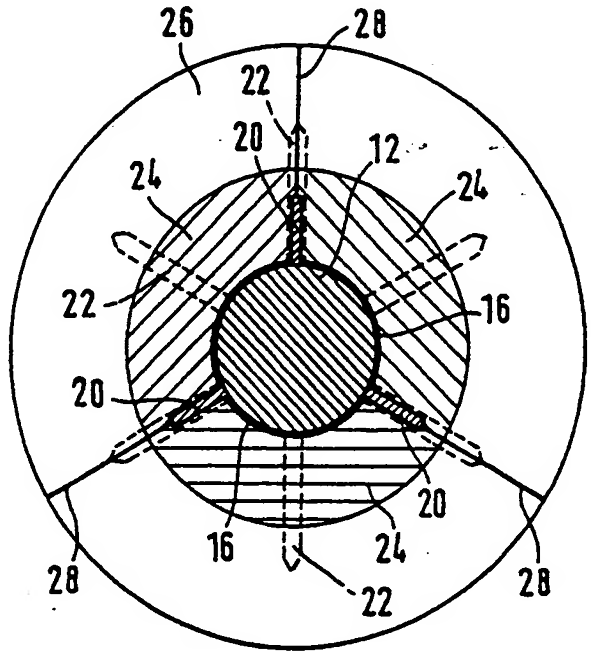


FIG. 2

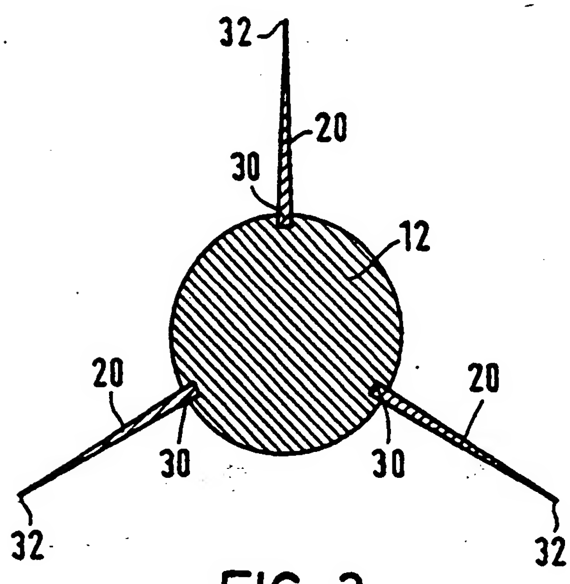


FIG. 3

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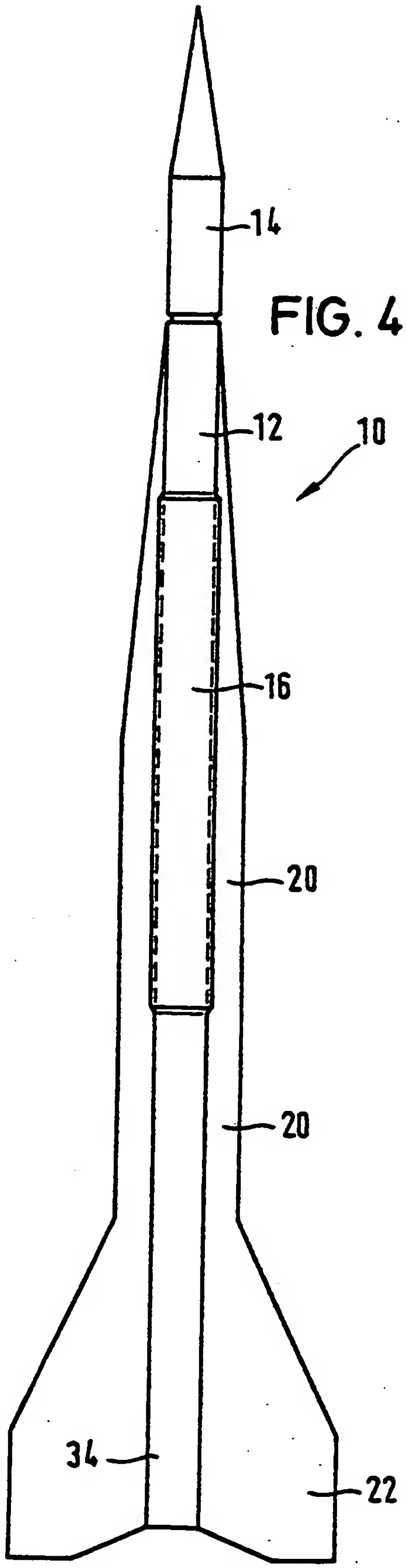


FIG. 4

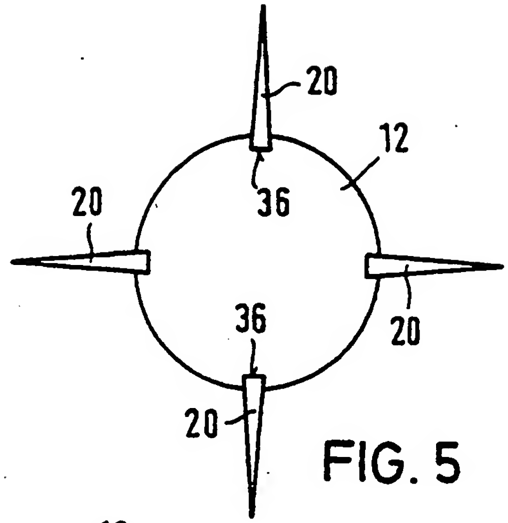


FIG. 5

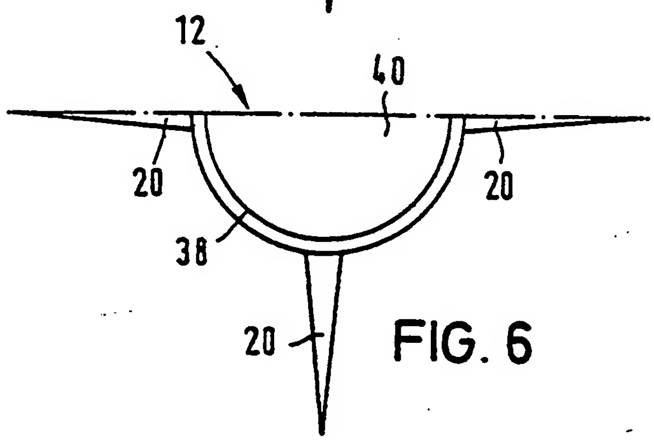


FIG. 6

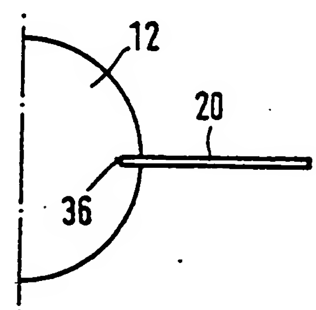


FIG. 7

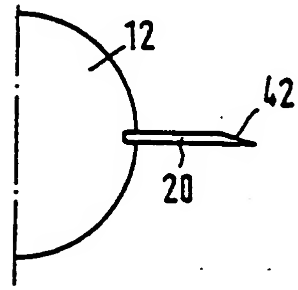


FIG. 8

FIG. 9

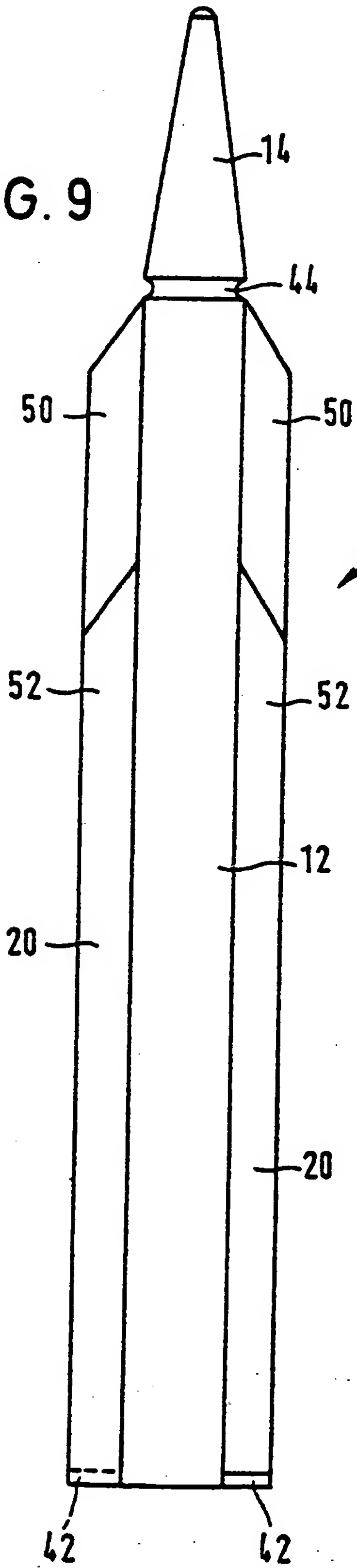
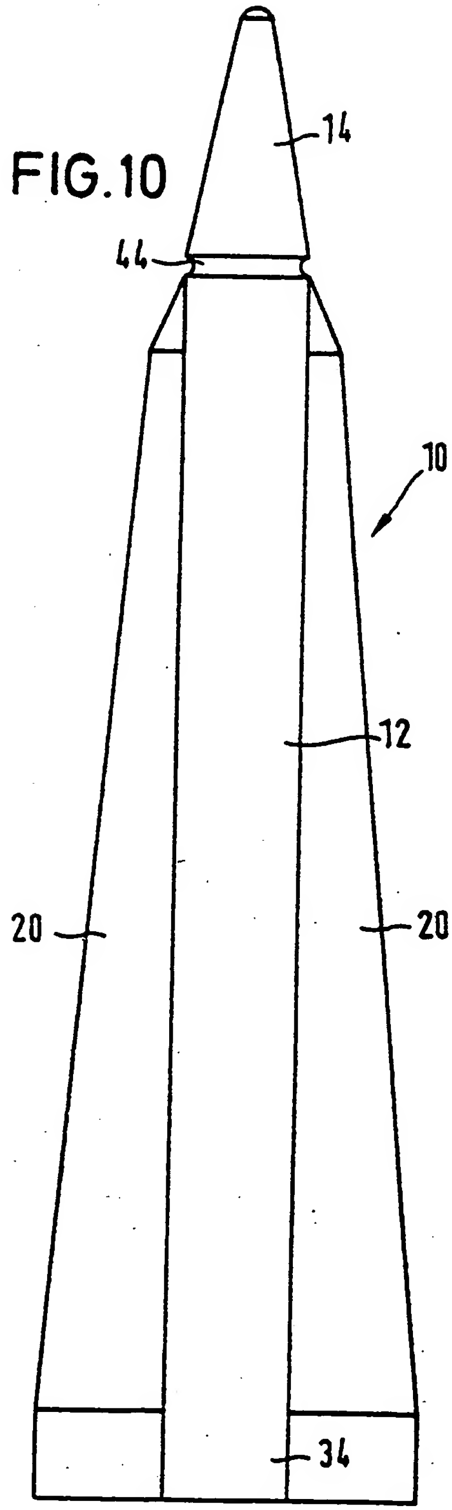


FIG.10



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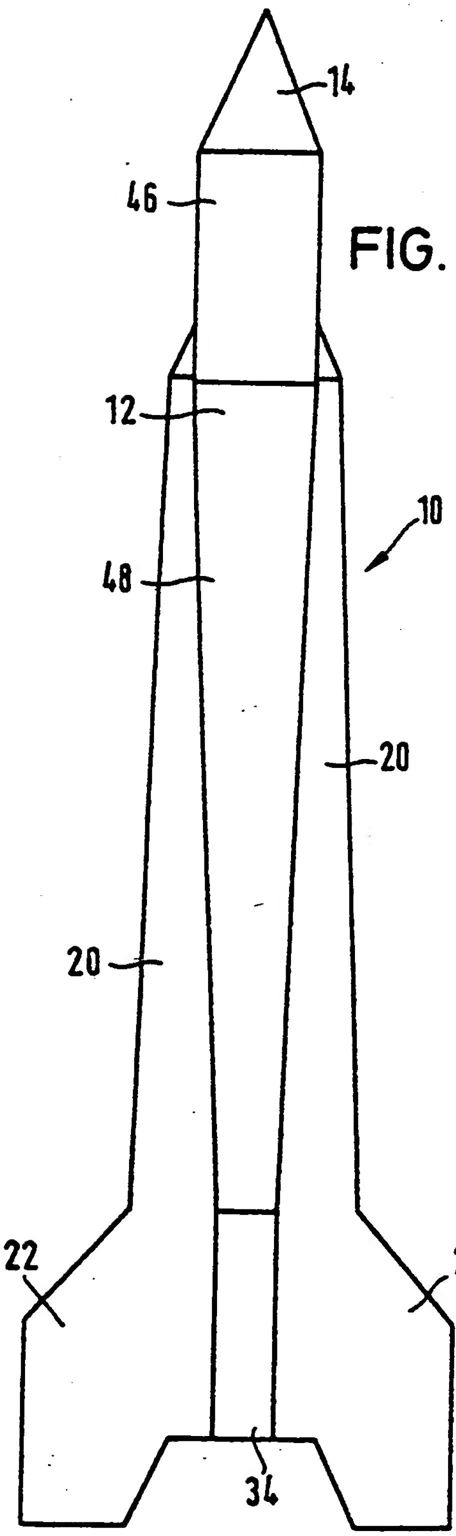

FIG. 11

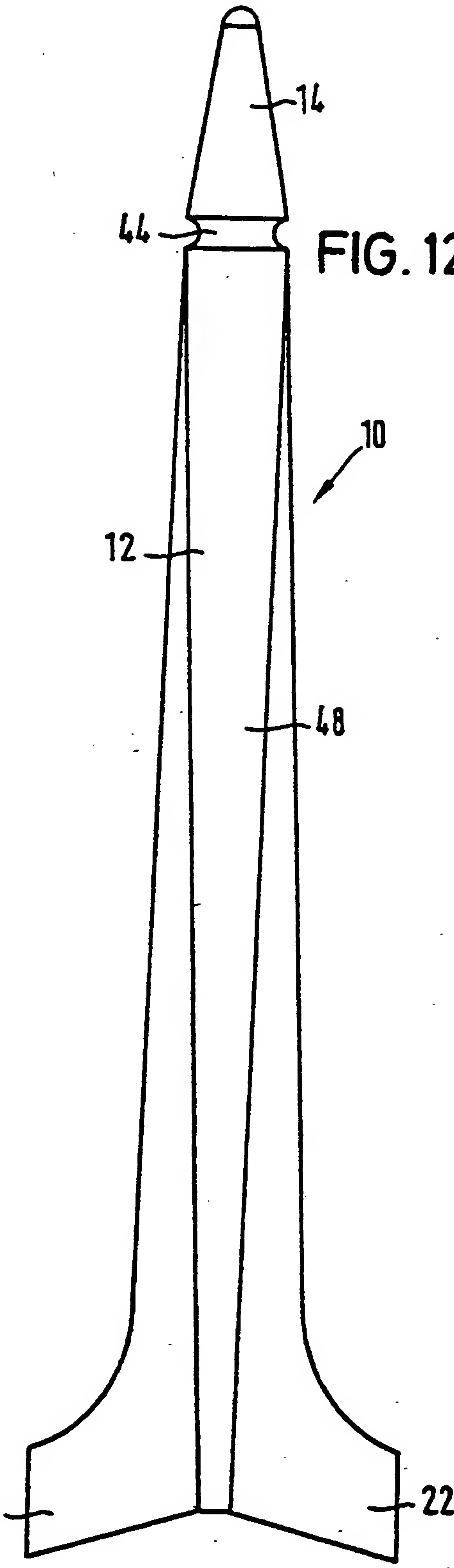

FIG. 12

TITLE

Penetrator Projectile

This invention relates to a fin stabilised kinetic or penetrator projectile having a projectile body with a length-to-diameter ratio of more than ten and with a segmented discarding sabot by which the projectile can be fired from a large calibre gun.

The firing of rod-shaped penetrator projectiles of ever increasing length and slenderness presents problems. The natural oscillation characteristics of a long rod-shaped projectile with a length to diameter ratio of over ten is a particularly critical factor. The minimum rotatory and torsional natural resonance frequencies of slender penetrators fall to lie in frequency ranges excited by vertical displacements, detachment interference of the sabot and excitations occurring during the flight. These low frequency excitations cause transverse oscillation of the rod during the flight phase, which can no longer be adequately restored, damped and compensated in the rod. The oscillations are liable to build up and can not only seriously detract from the final ballistic performance of the penetrator action, but may also cause failure or breakage before reaching the

target.

With known types of projectile account is not taken of the natural oscillation due to the intrinsic rigidity of relatively compact penetrators with short projectile bodies (a length to diameter ratio of less than ten).

This invention seeks to provide a projectile with a high slenderness ratio with sufficient intrinsic rigidity such that the natural resonance frequency is increased and there is less bending even during the flight phase.

According to this invention there is provided a fin-stabilised penetrator projectile having a body with a length to diameter ratio greater than ten and fired from a barrel using a segmented discarding sabot, wherein to increase fluxural bending resistance, the projectile body has at least three thin strips extending longitudinally over the external surface of the body.

The attachment of elongated stabilising strips to the projectile body ensures that penetrators with a high slenderness ratio can be fired and will retain stability during flight. The penetrator rod is provided over either a part of the length or over the entire length with elongated stabilising strips attached either directly to the penetrator or to a casing thereon. The geometric shape of the stabilising strips gives the penetrator a high overall rigidity over the entire length

and ensures that even during the flight phase it will have little tendency to oscillate.

The penetrator may be constructed to any required shape and have as high a slenderness ratio as desired. The increase in rigidity of the projectile body is achieved by the stabilising strips attached thereto. One particularly advantageous version comprises a penetrator rod with a massive and robust front end and a projectile body tapering in the direction of the tail end. This version offers not only aerodynamic but also ballistic advantages. The diameter of the tail fins can also be extended to correspond with the full calibre, so that the tail fins can serve as support struts and guide elements and thus form means for stabilising very long penetrators during the acceleration phase in the barrel.

The transmission of the force from the prevailing gas to the penetrator is carried out by a conventional sabot. The number of sabot segments depends on the number of stabilising strips attached. Three, four or more such strips can be provided to strengthen the penetrator and improve the dynamic guiding of the projectile body. Appropriate recesses may be provided on the sabot, preferably in the joints between the segments to receive the stabilising strips. For the transmission of the acceleration forces in the barrel

from the sabot to the penetrator rod it is possible to use screw-threaded or annular grooves on the penetrator of the customary type as well as the stabilising strips attached thereto.

If an additional steel casing is placed over the comparatively fragile tungsten core of the projectile body then a frictional connection between the casing and the penetrator must be provided. A special advantage of this arrangement concerns the conically tapering penetrator rod whereby an appreciable part of the acceleration forces can be transmitted, for example, by friction. In addition, the frictional connection between the casing and the penetrator should be positioned as far forward as possible. This procedure enables the connection to be separated rapidly during penetration of the armour plating of the target and the penetrator to thus detach from the casing.

The special advantages of the projectile to which this invention relates is clear from free flight. The natural frequencies of customary penetrator rods decrease with the increasing slenderness ratio and particularly with the increasing length of the rod. The rods thus become considerably more sensitive to low-frequency resonances to which the system is subjected, for example in the acceleration phase in a barrel, or as a result of

barrel jump, or due to resonances during the flight phase. This results in increased deflection of the penetrator rods during flight, which cannot be damped sufficiently by the rod itself. As a result of the continuous excitation of the rods at their critical natural resonant frequencies the oscillation in the system builds up which may lead to plastic deformation and even fracturing of the material.

As a means for increasing the rigidity of the penetrator, which not only increases the critical resonance frequencies but also reduces deformability and intensifies the restoring forces, this invention provides for the elongated stabilising strips along the length. This both improves the rigidity of the system and stabilises the flight characteristics of the penetrator rod. To position the centre of pressure more rearwardly the diameter of the rear part belonging to the stabilising strips and constructed as tail unit fins can be widened towards the rear. This increases the distance between the pressure centre point and the centre of gravity of the system and ensures more stable flight characteristics. Single-part stabilising strips with tail unit fins formed at the rear can be designed either with a constant fin height or with fins increasing in height towards the rear.

The construction of a massive penetrator head with a tapering rear part also results in the creation of a more forward centre of gravity to increase the distance from the centre of air pressure to the centre of gravity and thus stabilises the system still further. In those versions in which the cross section of the penetrator tapers the increase in the diameter ensures a constant and increased overall geometric moment of inertia.

The shape which is regarded as critical is that corresponding to the lowest natural resonant frequency.

The maximum oscillation usually takes place in the middle of the penetrator rod. Steps must therefore be taken to ensure that this point of maximum deflection is the very position in which the system is provided with sufficient flexural strength by constructing the stabilising strips to an adequate length and height.

The stable flight characteristics of the slender penetrator rod also offers considerable advantages from the point of view of final ballistics. The rod oscillating at low frequency encounters the target when in a comparatively undeflected state. The natural oscillation of the rod takes place at a negligible rate by comparison with the penetration process. The deflected state during the penetration of the target can therefore be regarded as static. The penetration

of the projectiles causes, on the impact front, the formation of a hydrodynamic state in which the projectile material in course of penetration causes outflow of target material and thus continuously buries itself in the target. The penetration process is maintained by the constant pressure caused by the penetrator mass which follows at an unreduced speed. The longer the rod the longer will this process be maintained and the further the penetrator will enter the target.

In the case of deformation by warping of the penetrator rod consequent on lateral deflection of the material following a lateral deflection between the following penetrator and the target armour, the limited penetration channel and the material also flowing back from the base of the crater formed may lead to additional friction and hindrances as a result of which the kinetic energy of the penetrator may be reduced or the penetrator even destroyed.

To prevent these effects the penetrator should be stabilised. For this purpose the invention provides for the rigidification of the penetrator by means of the attached stabilised strips. The only obstacle to the target penetration process resides in the larger diameter of the fins. These are braked when encountering the

surface of the target, thus reducing the speed of the penetrator mass enclosed. The forces required for shearing off the fins, however, are relatively small and thus practically negligible in comparison with the residual kinetic energy of the penetrator.

When using a casing to which the stabilising strips are affixed the aforementioned drawbacks of the shearing-off process can be almost eliminated. The rearward tapering shape of the penetrator rod proves particularly effective in this connection. When the system encounters the target the casing together with the fins is braked by the wall of the target and the penetrator discards the outer stabilising system in a simple manner, so that the penetrator can enter the target unimpeded. The conically tapering shape also reduces the angles of oscillation when the penetrator encounters the target. Friction within the penetrated channel, which in the event of a cylindrical shape may cause the penetrator to fail, is thus avoided.

The massive construction of the penetrator head also has an advantage when encountering armour plating at an angle or when penetrating active armour targets which make exacting demands on the shearing power of the penetrator. In these processes it is mainly on the nose of the penetrator that a force is exerted. The rear

zone of the penetrator serves to feed further material into the aperture opened up by the nose and to maintain the hydrodynamic process. Here again the shape of the penetrator rod offers considerable advantages. The fullest possible use is thus made of the mass which can be fired. The conical shape increases the length towards the rear by comparison with cylindrical projectiles, thus ensuring, in the middle of the penetration process, that further material will be caused to follow so that the aperture, although becoming smaller, increases in depth.

A decreasing penetrator diameter also enables the material flowing back to be discharged unimpeded and causes less friction with the penetrator body following up.

The inertia projectile which is made rigid by means of additional outer stabilising strips in accordance with the invention offers the advantage of making it possible to construct longer and more slender penetrators with a length to diameter ratio of over thirty which can be safely fired and will penetrate the target even more effectively. A long inertia projectile of this kind is illustrated, for example, on the left of P. 1809 in the "Internationale Wehrrevue 12/1986".

This invention also makes it possible, for example,

with a given overall length for the ammunition and projectile and with a shorter central primer (long inner detonating tube), to increase the length of the penetrator mass and thus intensify the effect on the target, by dispensing with a hitherto customary tail unit with a casing of steel or aluminium and by making the penetrator body longer at this point and also by constructing it of heavy tungsten metal, which is particularly effective on the target.

This invention is further explained in more detail by reference to embodiments shown as examples in the accompanying drawings.

In the drawings:-

Figure 1 shows a side view o. a penetrator according to the invention,

Figure 2 shows a cross section through a penetrator according to the invention with a discarding sabot indicated,

Figure 3 shows a cross section through a penetrator according to the invention on III-III of Figure 1,

Figure 4 shows a side view of a further penetrator according to the invention,

Figures 5,6,7 and 8 show cross sections and part cross sections through further embodiments

of penetrators according to the invention, and

Figures 9,10,11 and 12 show side views of further embodiments of penetrators according to the invention.

Referring to Figure 1, a fin-stabilised penetrator projectile 10 has a projectile body 12 with a length to diameter ratio greater than ten. The projectile body 12 has a nose 14 of slightly greater diameter with an interlock zone 16 of a customary type in the central portion comprising screw-threading or annular groove for transmission of acceleration forces from a segmented discarding sabot to the projectile body 12. A tail unit 18 of a conventional type is provided. To increase flexural strength the projectile body 12 according to the invention is provided in a central portion, which is subject to maximum deflection, with at least three thin stabilising strips 20 positioned along the outer surface of the body. To ensure effective stabilisation the strips 20 extend over at least one third of the entire length of the projectile body. In the case illustrated the length of the stabilising strips 20 is somewhat more than half the total projectile body length.

Figure 2 shows a cross section of a projectile body 12 in accordance with the invention, having three

stabilising strips 20, and six fins 22 forming the tail unit 18.

In the central part of the projectile body 12 the interlock zone 16 is formed on the periphery and is engaged by three sabot segments 24 with appropriately shaped screw-threaded or annular grooves. The large-calibre circumference forms the front guide flange 26 of a two-flange sabot of the usual kind. The sabot segments 24 take the form of 120° segments and are laterally delimited by separating plane 28. Each of the stabilising strips 20, for aerodynamic reasons, is positioned in front of a tail unit fin 22 of the tail unit 18 as viewed in the longitudinal direction.

Figure 3 shows stabilising strips 20 which have a wider cross-sectional base 30 to enable them to be secured to the projectile body 12 and which taper conically in the direction of their outer edges 32, the thickness of the sheet metal of the stabilising strips 20 thus decreases from the inside towards the outside.

Figure 4 shows a further penetrator 10 according to the invention. In this case each stabilising strip 20 is extended towards the rear and at the same time shaped to have increasing span and forming a single unit tail fin 22. The stabilising strips 20 increase in diameter from the nose 14 of the projectile to about the centre of

the projectile body 12 very gradually but at a constant rate. From the centre of the projectile body 12 rearwards the stabilising strips 20 are of constant diameter and towards the rear 34 of the projectile they increase considerably in diameter, thus taking the form of a large area single tail unit with fins 22.

Figure 5 shows a further cross section of a projectile body 12, although in this case the four stabilising strips 20 are symmetrically distributed around the periphery of the body. The stabilising strips 20 are inserted and secured in longitudinal grooves 36 provided on the outer surface of the projectile body. The stabilising strips 20 are preferably secured by welding or soldering.

In the simple version shown in Figure 7 the stabilising strips 20 are of rectangular cross section and are each soldered or brazed in a longitudinal groove 36 provided on the outer surface of the projectile body 12.

As a means of generating a slight compensating rotation the stabilising strips 20 of the projectile body 12 are provided, as shown in Figure 8, with a bevelled portion 42 on one side of their lateral outer edges 32 and/or rear outer edges.

A further constructional example of a penetrator 10

according to the invention is shown in Figure 9. In this case the projectile body 12 is mainly cylindrical and the stabilising strips 20 extend over the entire length of the cylindrical portion of the projectile body with constant width.

The stabilising strips 20 may advantageously comprise, in a front portion 50, a high temperature resistant material such as a steel alloy or titanium alloy with the rear portion 52 being made of a light metal alloy such as aluminium.

In another example, illustrated in Figure 10, the projectile body 12 is again mainly cylindrical, but the stabilising strips 20 widen towards the rear with a continuous increase in width or height over the entire length of the cylindrical portion of the projectile body.

In a further preferred example of a penetrator 10 according to the invention, shown in Figure 11, the projectile body 12, behind the nose 14, tapers conically towards the rear, preferably from an annular groove 44 which forms a preset break point (Figure 12), the diameter of the projectile body thus decreasing in the direction of the rear end.

Figure 12 shows a similarly designed penetrator 10. In this version the single part projectile body 12 is provided, following the nose 14, with a short cylindrical

projectile body part 46, the length being about two to four times the diameter of the projectile, with a projectile body shape 48 tapering conically towards the rear, the stabilising strips 20 being at the same time shaped, at the rear, as tail fins 22 having increased diameter.

The stabilising strips, for the purpose of economical quantity production, may consist of punched steel sheet parts or made of an appropriate dimensionally stable material.

The provision of stabilising strips on the outer surface of inertia projectiles having a high slenderness ratio in accordance with the invention gives the projectile body a high degree of intrinsic rigidity during the flight phase as well as increasing the natural oscillation frequencies of the penetrator and reducing the tendency to bend.

CLAIMS

1. A fin-stabilised penetrator projectile having a body with a length to diameter ratio greater than ten and fired from a barrel using a segmented discarding sabot, wherein to increase fluxural bending resistance, the projectile body has at least three thin strips extending longitudinally over the external surface of the body.

2. A projectile in accordance with Claim 1, wherein the strips extend over at least one third of the length of the projectile body.

3. A projectile in accordance with Claim 1 or 2, wherein each of the strips is positioned in longitudinal alignment with a tail fin.

4. A projectile in accordance with any one of Claims 1, 2 or 3, wherein the strips have a wider cross section at the base for attachment to the projectile body and taper towards the outer edge.

5. A projectile in accordance with any preceding claim wherein each strip has a rearward extension preferably of increasing height forming a tail fin.

6. A projectile in accordance with any preceding claim wherein four strips are symmetrically distributed around the periphery of the projectile body.

7. A projectile in accordance with any one of the preceding claims wherein the projectile body has a core of shatterable heavy metal and a thin outer casing of a more ductile material, such as steel, to which the strips are secured.

8. A projectile in accordance with any one of the preceding claims wherein the strips have a rectangular cross section and are each secured in a longitudinal groove in the external surface of the projectile body.

9. A projectile in accordance with any one of the preceding claims wherein the strips are provided on one side of their lateral outer edges and/or their rear outer edges with a bevelled portion to generate a rotational force.

10. A projectile in accordance with any one of the preceding claims, wherein the projectile body is of substantially cylindrical shape, the strips having a constant width over the entire length of the cylindrical

zone of the projectile body.

11. A projectile in accordance with any one of the preceding claims wherein the projectile body has a substantially cylindrical shape, the strips extending towards the rear with a decreasing width over the entire length of the cylindrical zone of the projectile body.

12. A projectile in accordance with any one of the preceding claims wherein the projectile body tapers conically from behind the nose to the tail and preferably has an annular groove forming a preset fracture point between the nose and body.

13. A projectile in accordance with any one of the preceding claims wherein the projectile body behind the nose has a short cylindrical part of length two to four times the projectile body diameter, which tapers conically towards the start of the strips, the strips at the rear end forming tail fins.

14. A projectile in accordance with any one of the preceding claims wherein the strips comprise at the front a high temperature resistant material such as a steel alloy or titanium alloy and at the rear a light metal

alloy, such as aluminium.

15. A projectile constructed and arranged to function as described herein and exemplified by the drawings.

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